4. EVALUATION OF PROGRAM FOR CONSTRUCTION ACTIVITIES

This chapter evaluates the impact of the construction activities segment of the Phase I storm water program. Several studies reveal that storm water runoff from construction sites can include a variety of pollutants, such as sediment, bacteria, organic nutrients, hydrocarbons, zinc, copper, cadmium, mercury, iron, nickel, and oil and grease (Barret et al., 1996). In addition, the *National Water Quality Inventory: 1996 Report to Congress*, found construction activities (e.g., land development, road construction) to have a significant impact on lakes and wetlands (USEPA, 1998).

During storms, construction sites can be the source of sediment-laden runoff, which can overwhelm a small stream channel's hydraulic carrying capacity, resulting in streambed scour, streambank erosion, stream "blow out," and destruction of near-stream vegetative cover. As the flow velocity decreases, sediment from construction site runoff settles out, blanketing stream beds, burying macroinvertebrates, and eliminating the natural stream substrate. Streams that are overwhelmed by runoff can become wider. Consequently, they exhibit shallower base flow, lose their natural riffle-run morphology, lose the vegetative cover that shades the stream and mitigates temperature swings, and lose their value as habitat for aquatic species. The recurrence of high storm water flows maintains these degraded conditions, ultimately resulting in water quality and habitat degradation. The prevention of sediment and flow runoff from construction sites mitigates this degradation (USEPA, 1999b).

Although small streams are frequently the first water bodies with which storm water comes into contact, these streams subsequently drain into *larger streams, rivers, ponds, lakes, wetlands, bays, estuaries, or oceans*. Thus, stream reaches affected by construction activities often extend well downstream of the construction site. For example, between 3.0 and 3.5 miles of stream below construction sites in the Patuxent River watershed were observed to be impaired by sediment inputs (Klein, 1979). It is near these downstream water bodies that a large share of the population lives or participates in water-dependent recreation. When small-stream habitat and water quality degrade, the downstream systems also are affected, resulting in poor water quality and decreased upstream habitat for aquatic species. When small-stream habitat and water quality improve, downstream water bodies also realize water quality and habitat improvements, resulting in benefits for the population living nearby or using the resource for recreation, as described below.

Construction fundamentally alters natural landscapes (Toy and Hadley, 1987). During construction, earth is compacted, excavated and displaced, and vegetation is removed. These activities increase runoff and erosion, thereby increasing the amount of sediment transported to receiving waters. Siltation has been identified as the leading process affecting rivers and streams in the Nation (USEPA, 1998). Although agriculture produces the largest sediment load, construction results in the most concentrated form of erosion, and the rate of erosion from construction sites can exceed that from agricultural land by 10 to 20 times (WEF and ASCE, 1992). Although erosion and sedimentation are natural processes, when land is disturbed by construction activities, surface erosion increases up to10 times on sites formerly used for crop agriculture, up to 200 times on sites formerly under pasture, and up to 2,000 times on sites formerly forested (Toy and Hadley, 1987). In addition to sediment, construction activities also yield pollutants such as pesticides, petroleum products, construction chemicals, solvents, asphalts, and acids, which can contaminate storm water runoff (Marsh, 1993).

Numerous studies have examined the increases in sediment loads resulting from storm water runoff. For example, Daniel et al. (1979) monitored three residential construction sites in southeastern Wisconsin and determined that annual sediment yields were more than 19 times greater than yields from agricultural areas. Yorke and Herb (1978) studied nine sub-basins in the Maryland portion of the Anacostia River watershed for more than a decade to determine the impacts of changing land use and land cover on runoff and sediment. Average annual suspended sediment yields from construction sites ranged from 7 to 100 tons per acre, as compared to yields from cultivated land and forest/grassland, ranging from 0.65 to 4.3 tons per acre and 0.07 to 0.45 tons per acre, respectively. A 1970 study conducted by the National Association of Counties' Research Foundation found the potential impacts of urban and suburban development to be even more dramatic. The Foundation concluded that sediment yields from construction areas could be as much as 500 times the levels detected in rural areas (National Association of Counties Research Foundation, 1970).

The remainder of this chapter describes EPA's analysis of the storm water program for discharges from construction activities. Section 4.1 of this chapter describes the Phase I requirements for construction activities. Section 4.2 discusses the general methodology and primary data sources. Section 4.3 presents the specific methods used to determine the impacts and the results of these analyses. Section 4.4 presents the overall findings, including a discussion of program elements considered successful and those considered unsuccessful.

4.1 STATEMENT OF PHASE I REQUIREMENTS

Construction site runoff is addressed by the Phase I program through two major mechanisms. First, as noted in Chapter 3, Phase I municipalities (MS4S) address construction site runoff within their jurisdiction. Second, as described below, sites of similar size outside these jurisdictions are covered under the program by NPDES permits. This chapter identifies the programmatic, pollutant loading, and water quality improvements associated with both of these regulatory mechanisms for runoff from construction activities.

The Phase I storm water regulations (55 FR 47990; November 16, 1990) requires operators of construction activity that will disturb 5 or more acres of land to:

- Obtain a National Pollutant Discharge Elimination System (NPDES) permit for discharges of storm water from construction activities to either an MS4 or waters of the United States.

- Develop a storm water pollution prevention plan (SWPPP) to control erosion and sediments, litter and construction debris, and construction chemicals on construction sites.

In developing a permitting approach for storm water discharges associated with construction activities regulated under the Phase I program, EPA acknowledged the administrative burden on EPA and States authorized to implement the NPDES program to provide permit coverage for a large number of sites. Consequently, EPA and authorized States have primarily relied on the use of general permits to provide permit coverage. The primary permit condition to address the discharge of pollutants from construction sites is the requirement to develop an SWPPP that addresses the following items:

- A description of potential pollutant sources and other information such as a description of the nature of the construction activity.

- A description of the intended sequence of major activities that disturb soils on major portions of the site.

- Estimates of the total area of the site that is expected to be disturbed.

- An estimate of the runoff coefficient of the site for both the preconstruction and post construction conditions, and data describing the soil or the quality of any discharge from the site.

- A general location map, as well as a site map indicating drainage patterns, approximate slopes after grading, areas of soil disturbance, locations of major structural and nonstructural controls, locations where stabilization practices are expected to occur, and locations of off-site material.

- Waste, borrow, or equipment storage areas.

- Surface waters, including wetlands.

- Locations where storm water discharges to a surface water.

- The location and description of any discharge associated with industrial activity other than construction.

- The name of the receiving water(s) and the areal extent and description of wetlands or other special aquatic sites at or near the site that will receive discharges from areas disturbed by the project.

- Information on whether listed endangered or threatened species, or critical habitat, are found in the proximity and whether such species might be affected by the applicant's storm water discharges or storm water discharge-related activities.

Each SWPPP must include a description of appropriate control measures (i.e., best management practices) that will be implemented to control pollutants in storm water runoff. In the case of construction activities, control measures include the following:

- Erosion and sediment controls designed to retain sediment on site.

- Controls that prevent construction debris and construction materials from becoming a pollutant.

- Interim and permanent stabilization practices to preserve existing vegetation; establishment of temporary vegetation and other techniques to minimize the exposure of soils to erosion;

- Structural practices to divert flows from exposed soils or otherwise limit runoff and the discharge of pollutants from exposed areas.

- Measures to be installed that will control pollutants in storm water runoff in the post construction period.

4.1.1 Current Status of Construction Activities Covered under the Phase I Program

One factor necessary in evaluating the success of the Phase I program is the number of construction starts regulated under the program. EPA searched its Notice of Intent (NOI) database and surveyed the EPA regions to estimate the number of construction starts nationwide. The NOI database tracks permit applications for construction starts in States where EPA is the permitting authority. The EPA regions provided the total number of construction starts in authorized States. These efforts identified 111,291 construction starts that have applied for permit coverage since 1994.[1] For 1999 the data searches and information requests identified 17,292 construction starts nationwide. To provide an estimate of the number of permitted starts in 1999 for States that did not provide data, an average of the reported data over the years of the program was developed. For 1999 the estimate of the number of permitted construction starts is 19,856 nationwide.

Using the methodology from the Economic Analysis developed for the Phase II Storm Water Rule (USEPA, 1999b), EPA estimates that Phase I storm water program applies to roughly 62,755 construction starts annually. This approach to estimate the number of construction starts is also used for the load reduction analysis (Section 4.3.2).

4.2 ANALYTICAL APPROACH

This analysis provides an understanding of improvements associated with implementing BMPs and activities associated with the Phase I storm water construction program. The analysis does not differentiate between the efforts of Phase I municipalities to address construction activities, those permitted under an applicable NPDES general permit, or regulated under other state and local sediment and erosion control programs. The analysis characterizes key program elements used to achieve the load reductions and water quality improvements. Where possible, the analysis projects national trends.

As discussed in Chapter 2, three indicators are used to identify program success:

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[1] Of the 54 States and territories, only 45 provided construction start data.

- **Programmatic indicators** show the degree to which communities have implemented construction storm water management programs responsive to local needs.

- **Loading reductions** are estimates of pollutants averted due to installation, operation and maintenance of structural and non-structural BMPs.

- **Water quality improvements** are estimates of reductions in pollutant concentration levels related to storm water controls.

4.3 SPECIFIC METHODS AND RESULTS

This section provides the specific methods and presents the results of EPA's analysis of the Phase I program for storm water discharges from construction activities.

4.3.1 Programmatic Indicators

Case studies collected for the purposes of this Report provide specific examples of how the flexibility in the Phase I storm water program for construction activities has helped communities. As noted in Section 4.1, the program was specifically constructed to be as flexible as possible, allowing local and State jurisdictions to be as innovative as possible in achieving desired results. Survey results and case studies indicate that the Phase I program has fostered significant innovation, often in combination with other Federal, State, and local erosion and control programs. Innovations are demonstrated by the fact that surveys and case studies illustrate that the program has:

- Enabled State and local jurisdictions to both integrate and leverage the Phase I program with other programs.
- Promoted cost efficiencies in program development and administration.

4.3.1.2 Case Studies

EPA acknowledges the limited nature of this survey. Consequently, for purposes of this Report, EPA was able to collect five case studies that demonstrate various aspects of programmatic success. These case studies provide some illustration of the flexibility of the program and how municipalities and States have used existing erosion and sediment control programs to meet and exceed Phase I requirements. The case studies include examples of where leveraging Phase I with other related programs provides water quality benefits, promotes cost effective programs, and delivers overall economic benefits to the developer and community. Complete copies of the case studies are provided in Appendix D.

North Carolina Leverages the Phase I Program with Other Soil and Erosion-Control Programs to Yield Water Quality Benefits

The State of North Carolina's Sedimentation Control Program has been in place since 1973. Under this program, the State requires effective sediment erosion controls to prevent inhibition of aquatic plant growth, disruption of fish nests, and the introduction of toxins into the water. The North Carolina Sedimentation Control Program regulates construction activities equal to or greater than 1 acre. The North Carolina program is thus more stringent than the Phase I program, which limits its jurisdiction to sites equal to or greater than 5 acres.

Within the North Carolina Department of Environment and Natural Resources (NCDENR), the Division of Land Resources (DLR) is responsible for administering the Sedimentation Control Program and the Division of Water Quality (DWQ) is responsible for administering the Phase I storm water program. Although NCDENR staff state that integrating the two programs is not always easy, they believe having the Phase I program in conjunction with the State Sedimentation Control Program is ultimately beneficial. The Phase I program has helped to open the lines of communication between DWQ and DLR.

The two departments recently joined forces to stop poorly managed construction activities in a portion of Brunswick County, North Carolina. Ditching activities had resulted in the improper drainage of nearly 1,500 acres of wetlands. Through inspections, DLR and DWQ determined that the developers had not prevented off-site sedimentation from the ditching activities. The activities not only had resulted in a loss of wetlands but also had caused exceedances of the turbidity standard in Beaverdam Creek, a primary nursery area and high-quality water. A settlement reached between DWQ, DLR, and the developers included the restoration of the drained wetlands and $213,000 in fines and enforcement costs.

The Brunswick County situation in North Carolina illustrates how the Phase I program is an important component of an overall suite of water quality protection programs. "The construction general permits we issue under the Phase I construction program are an important piece to a comprehensive construction storm water control program," stated Bradley Bennett, the supervisor of the storm water unit within DWQ. "The Sedimentation Control Program focuses on the primary pollutant from construction sites, but does not address the other possible pollutants that could originate from construction equipment and other activities on site. Under the provisions of the construction general permit, construction site operators must also think about good housekeeping practices to prevent contaminating runoff with fuels, lubricants, pesticides, and other related materials."

> "Historically, the Departments of Water Quality and Land Resources have had limited interaction, despite the fact the departments have similar goals regarding construction site runoff control. The construction general permit required under the Phase I program has been a mechanism to bring different environmental programs together."

New Castle County, Delaware Expands Its Cost-Effective Approach to Program Implementation

The Sediment and Storm Water Program of the Delaware Department of Natural Resource and Environmental Control (DNREC) illustrates how an aggressive inspection program built on privately employed inspectors can ensure construction control compliance. The result is a win-win situation where the environment is protected. To obtain the mandated construction inspection, developers can hire one of the hundreds of private inspectors licensed under the State's Certified Construction Reviewer (CCR) program, first implemented in 1992.

> Officials estimate that the increased compliance as a result of the CCR program inspections prevents 84 percent of the sediment that would otherwise reach Delaware's waters.

In New Castle County, the CCR program has been a successful component of the County's overall storm water management program. New Castle County enjoys a healthy economic growth rate, as indicated by the approximately 400 construction sites per year that require development and implementation of a detailed Sediment and Storm Water Plan. Because of the incorporation of CCRs, county staff time once spent on construction site inspections can now be more cost-effectively spent overseeing the private CCR inspection process. Through the CCRs program, New Castle County reports an improved compliance rate while at the same time saving approximately $100,000 annually. Studies have shown that erosion and sedimentation controls in New Castle County reduce the sediment in runoff an average of 84 percent, which equates to an estimated 600,000 tons annually of sediment retained from the 400 construction starts in the County.

California Demonstrates That Phase I Can Accommodate Alternative, Less Burdensome Permitting Approaches

The nature of Phase I storm water regulations and the Department of Transportation (DOT) MS4 systems resulted in DOT's holding MS4 permits in multiple Phase I cities. The different permits created confusion that resulted in unnecessary delays in highway construction. In 1996, to ensure a more uniform storm water program, California's Department of Transportation (Caltrans) requested that the California NPDES permitting authority, the State Water Resources Control Board (SWRCB), consider adopting a *single* NPDES permit for all storm water discharges from Caltrans properties, projects, and activities. Caltrans, EPA Region 9 and the SWRCB worked together to develop the required permit language, and on July 15, 1999, the SWRCB approved the final Caltrans statewide NPDES permit. The permit covers the Construction General Permit (CGP) and MS4 permit requirements as well. Prior to this cooperative action, nine different MS4 permits had been held by various Caltrans Districts, and there had been no statewide, standard procedure for CGP compliance.

Caltrans is confident that it can meet the challenges of its new permit through the implementation of its new statewide comprehensive Storm Water Management Program (SWMP). The SWMP requires consideration of the most advanced BMPs, design/construction techniques and maintenance procedures for all Caltrans properties. This creates uniformity in site plans throughout the State. To ensure maximum protection of State waters, Caltrans is conducting research and monitoring studies to identify the most efficient erosion control and vegetation management BMPs available. The resulting information will be available to other DOTs and permittees. Caltrans also is developing a geographic information system (GIS)-based database to provide information on all watersheds, water bodies, and the associated water quality standards. The database will assist in the new watershed-level highway construction project planning process outlined in the SWMP. This planning mechanism also will encourage cooperative partnering between regulators, local community groups, municipalities and transportation entities.

Emphasis on Education in Garland, Texas, Results in Improved Compliance

The city of Garland, Texas, started its erosion and sediment control program in 1993 in response to NPDES permit requirements. One of the first steps was the publication of a construction BMP manual. The most prominent developers in the area were included in the development of the handbook and program, and that approach seems to have contributed to acceptance of the handbook and program by the community, according to Philip Welsch, Garland's Storm Water Coordinator. Garland's erosion and sediment control program requires BMPs on sites as small as 5,000 square feet and detailed site plans for all sites of 1 acre or larger. "Implementation of BMPs has definitely improved as a result of this program," said Welsch. "Erosion control on construction sites was basically nonexistent before that time."

Garland, in conjunction with seven other Dallas/Fort Worth area Phase I cities and the North Central Texas Council of Governments, also developed a training curriculum on the construction general permit requirements and local erosion and sediment control techniques.

Chattanooga, Tennessee, Establishes Strong Compliance Education Programs

The erosion control program in Chattanooga Tennessee, is relatively young and has drawn from other municipal storm water management programs in developing three components: erosion control requirements, contractor education and enforcement. Anticipating the proposed Phase II rule, the city sets no lower limit for its program and requires erosion and sediment control measures to be functional before activity begins and to be maintained throughout construction. When work is completed, the owner must make sure that the site is as erosion-free as practicable, establishing permanent vegetative cover where no other permanent stabilization technique has been used. Permanent certificates of occupancy are not granted until either the site is stabilized or a letter is received from the developer specifically detailing stabilization plans and time frames.

The city's public works staff discovered that achieving contractor compliance with these measures would be difficult. Chattanooga first developed education programs and attempted on-site training sessions. When the sessions did not produce significant improvement, the city, with initial assistance from the Chattanooga Home Builders' Association, established the Erosion Control School. In a free, 4-hour session, developers learn the city's requirements, as well as cost-effective ways to achieve compliance. Tests before and after the course measure students' understanding and information retention levels. Those who pass the second test receive a certification card. In 5 years, the school has certified nearly 300 people associated with all aspects of development. The city has received very positive responses not only from builders who have attended the class but also from local officials who wish to develop similar programs in their municipalities.

4.3.2 Loading Reductions

This section presents the results of a modeling analysis that projects loading reductions from implementation of the construction component of the Phase I program. The Phase I rule regulates construction starts disturbing 5 or more acres of land, requiring construction site owners or operators to plan and implement appropriate erosion and sediment control BMPs. Thus, the construction requirements prevent the degradation of water quality due to runoff and deposition of sediments released from construction sites.

> Phase I program implementation prevents an estimated 3 million tons of sediment from reaching our Nation's waters.
>
> *This loading reduction equates to more than 264,000 standard dump trucks of soil being kept out of the Nation's waters.*

To develop an estimate of sediment loadings from Phase I construction sites (i.e., disturbing 5 acres or more) and the loads averted by the implementation of BMPs, EPA estimated the total number of Phase I construction starts for the year 1999. Then, to approximate per-start sediment loads, EPA used an earlier analysis performed by the U.S. Army Corps of Engineers (USACE) for Phase II construction starts entitled *Analysis of Best Management Practices for Small Construction Sites* (USACE, 1998). The methodology followed is consistent with the *Economic Analysis for the Final Phase II Storm Water Rule* (USEPA, 1999b).

EPA used building permit information from the U.S. Bureau of the Census and construction start data from 14 municipalities around the country to estimate the number of 1999 construction starts greater than 5 acres.[2] Estimates from these 14 municipalities of disturbed area per construction start were then extrapolated to the universe of national construction starts based on data obtained from the U.S. Bureau of the Census on national building permits. The Census data provides building permit data for approximately 96 percent of the counties in the United States. Data files were obtained for the years 1980 to 1995. EPA anticipates that this estimate accounts for Phase I reported sites and sites that have not complied with Phase I reporting requirements. Note that some of the latter may still be implementing sediment and erosion control measures through local programs.

To eliminate double counting of programmatic results with other parallel programs (e.g., the Coastal Zone Act Reauthorization Amendments of 1990, or CZARA), EPA eliminated some localities that were required to have erosion and sediment control programs similar to the Phase I program. For example, no data for load estimates were generated for the climate zone represented by Hawaii in the analysis because the entire State is covered by CZARA. There are other equivalent programs in addition to those mandated under the Coastal Nonpoint Pollution Control Program. EPA identified state programs with similar requirements for sites that disturb 5 or more acres, and they were also removed from the analysis.

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[2] The 14 localities that provided construction start data were Austin, Texas; Baltimore County, Maryland; Cary, North Carolina; Fort Collins, Colorado; Lacey, Washington; Loudoun County, Virginia; New Britain, Connecticut; Olympia, Washington; Prince George County, Maryland; Raleigh, North Carolina; South Bend, Indiana; Tallahassee, Florida; Tucson, Arizona; and Waukesha, Wisconsin.

Pollutant loading reductions from Phase I construction starts were estimated with and without Phase I controls (USACE, 1998). Sediment delivery loads were estimated for 18 climatic regions under several scenarios: two site sizes (5–10 and >10 acres), three soil erodibility levels (low, medium, and high), three slopes (3, 7, and 12 percent). The 18 climatic regions were used in an effort to represent the various climatic conditions throughout the United States. To adapt the USACE analysis to the Phase I universe, EPA modified the length-slope factor to reflect the larger construction sites regulated under Phase I and used the same parameters for the remaining model assumptions.[3]

Using EPA guidance on storm water management for construction activities (USEPA, 1992b), combinations of BMPs for the model sites were developed to mimic commonly accepted erosion and sediment control practices. Additionally, BMPs were selected based on guidance contained in Brown and Caraco (1997).

Average sediment load per climatic region for Phase I construction sites with moderately erodible soil were determined. Then, the average loads per climatic region were multiplied by the ratio of total Phase I construction starts in each climatic zone to the total Phase I construction starts nationwide to obtain a national weighted average sediment load per site. This methodology was used to calculate sediment loads from construction starts with and without Phase I controls. These values are presented in Table 4-1.

The annual average soil loss per site without the Phase I program was 63.4 tons (3,977,518 tons/62,755 starts), and the potential reduction in annual average soil loss could be up to 46.4 tons per site with Phase I BMPs (2,911,523 tons/62,755 starts). The analysis concluded that 73 percent of the sediment that would otherwise be delivered into the Nation's waters is retained on construction sites due to controls implemented pursuant to Phase I requirements.

[3] The estimated amount of disturbed area for the 5–10 acre category was 7.5 acres; for the 10 acre and above category, 13.9 acres.

Table 4–1. Sediment Load Averted by Phase I BMP Implementation by Climatic Zone

Representative City	Climate Zone	Starts/ Year	Potential Load (Tons/Year)	BMP Reduced Load (Tons/Year)	Load Averted (Tons/Year)	Percent Load Averted
Portland	A	655	15,383	3,076	12,307	80.0
Boise	B	1,211	4,679	853	3,826	81.8
Fresno	C	0	0	0	0	0.0
Las Vegas	D	6,034	13,987	761	13,226	94.6
Denver	E	2,963	41,436	8,879	32,558	78.6
Bismark	F	807	14,027	2,892	11,135	79.4
Helena	G	1,691	7,804	1,435	6,369	81.6
Amarillo	H	3,998	151,975	40,458	111,517	73.4
San Antonio	I	1,098	110,993	33,111	77,882	70.2
Duluth	K	4,047	139,603	29,883	109,721	78.6
Des Moines	M	12,943	808,733	217,207	591,526	73.1
Nashville	NPDES	11,676	1,053,803	292,870	760,932	72.2
Atlanta	P	8,715	1,037,969	284,643	753,327	72.6
Hartford	R	3,877	191,866	44,950	146,916	76.6
Charleston	T	2,308	385,260	104,978	280,281	72.8
Hawaii	V	0	0	0	0	0.0
Alaska	W, X, Y	155	0	0	0	0.0
Atlantic Islands	Z	578	0	0	0	0.0
	TOTAL	62,755	3,977,518	1,065,995	2,911,523	73.2

To evaluate the Phase I programs's success in sediment load reduction for construction starts that have met reporting requirements, the NOI construction start data were also used in the load reduction analysis. Using the average sediment load reduction per site (46.4 tons per site) and estimates of the number of permitted construction starts in 1999 developed from the NOI database (19,856 sites), this analysis indicates that Phase I program has prevented up to 882,000 tons of sediment from entering the Nation's waters. Using the number of reported 1999 NOIs as a lower bound estimate and the total estimated number of potential Phase I construction starts as an upper bound estimate, the total amount of sediment prevented from eroding into the nations waters is 1999 was between 882,000 and 3 million tons.

4.3.3 Water Quality Improvements

Implementation of construction site BMPs is directed toward protecting and improving the water quality and physical condition of both small streams and larger water bodies. Runoff from construction sites may be particularly damaging to *small streams* because of the streams' typically small flow volume and channel size, which lessen the stream's ability to accommodate high flows and large sediment loads (USEPA, 1999b). EPA estimates that over one percent of all water bodies suffer major impairments from construction activities and has identified siltation as the leading pollutant or process degrading rivers and streams in the Nation (USEPA, 1998).

Water quality benefits that can result from construction control programs range from reduced pollutant loadings to increased habitat preservation to increased navigational benefits from reduced dredging of sediments. Currently, these benefits can only be estimated demonstrated by case studies and by statistical analyses.

First, a case study of how the State of Washington is using the Phase I program to protect water quality is provided. Then a statistical analysis is provided that looks at the relationship between construction starts, storm water controls, and receiving water quality. In the absence of sufficient data regarding water quality conditions before and after the Phase I program, the analysis uses Florida's CZARA program as a surrogate for Phase I to study the relationship between erosion control and water quality. A comparison of water quality and construction start data indicates that there is a positive relationship between implementation of construction erosion and sediment controls and reduction of total suspended sediment monitoring.

4.3.3.1 Case Studies

Ensuring Responsible Development in Grays Harbor County, Washington Results in Water Quality Protection

The siting and development of the Stafford Creek Corrections Center in Grays Harbor County, Washington, did not occur without controversy. The mixed emotions of county residents stemmed from a conflict between the desire for economic development and concerns about degrading the Grays Harbor Estuary, a water body currently listed as impaired on EPA's section 303(d) list of impaired waters. Construction of the facility requires disturbing approximately 210 acres along Stafford Creek, a tributary of the Grays Harbor Estuary that drains 1,100 acres and contains valuable salmon and oyster habitat as well as wetland resources. Although local supporters of the facility recognized the potential adverse impacts on the aquaculture industry, they understood the importance of bringing at least 650 additional jobs into the area.

Federal, State, and local stakeholders involved in the Stafford Creek Corrections Center proposal worked together to see that both economic development and environmental protection in Grays Harbor County would be possible. The storm water construction permit, as required by the Phase I program, provided a mechanism to ensure that the

> *The State of Washington Uses Phase I to Protect Its Waters*
> Washington's Department of Ecology has found the Phase I program to be instrumental in addressing discharges to valuable ecological and drinking water resources. For example, the Phase I program was used to address several affected areas:
> - Murky runoff draining from Issaquah Heights, a 3,250-home construction project, into Issaquah Creek and threatening the local water supply.
> - Damage to Valley Creek caused by a torrent of mud that washed off a Washington State Department of Transportation construction site.
> - Turbid water draining into Salmon Creek, an important habitat for endangered steelhead trout, from the Battle Ground Market Center construction site.

development of the facility would not threaten the nearby wetlands and salmon habitat of Stafford Creek and other surrounding water bodies. The most important requirement of this permit was the development and implementation of an SWPPP. Although the Washington Department of Ecology (WDEC) does not typically review and approve SWPPPs, it can review SWPPPs for projects that may pose a significant water quality concern. The Department of Ecology worked with the Washington Department of Corrections (DOC) to develop a SWPPP that would, when implemented, successfully control sediment-laden runoff from the construction site. Under the Phase I program, development and implementation of a SWPPP are enforceable permit conditions.

Construction of the Stafford Creek Corrections Center began in June 1998, and storm water runoff problems started with Washington's rainy season in the fall. Beginning in October 1998, the DOC reported exceedances of the turbidity water quality standard. Inspections conducted by WDEC between November 1998 and February 1999 revealed that the DOC was not fully implementing its SWPPP. For example, although the SWPPP required construction to stop during the winter rainy season, construction activities continued beyond October and into the winter to meet the scheduled opening date of the facility. Some of the BMPs described in the SWPPP were either not in place on-site or were not receiving proper maintenance. As a result of improper storm water control activities, a slope failure occurred that covered 0.2 acres of a nearby wetland. Monitoring and reporting during this period, conducted by both the DOC and local college students, documented the frequency and magnitude of violations. By February 1999, the DOC had reported 62 violations.

The DOC invested significant time and money in addressing problems on its site and implementing its SWPPP. According to monitoring and reporting data, that investment paid off in improved storm water quality. As shown in the adjacent text box, DOC reported more than 10 exceedances of turbidity standards each month between November 1998 and February 1999. In contrast, DOC did not report any exceedances between March and

Monthly Exceedances of the Water Quality Standard for Turbidity Reported to the Washington Department of Ecology by the Washington Department of Corrections

Month (1998 — 1999)	Number of Exceedances Reported
November	14
December	15
January	11
February	22
March (SWPPP fully implemented and turbidity problems addressed)	0
April	0

Source: Washington Department of Ecology

April 1999, after construction workers had fully implemented the SWPPP and addressed the problems on-site.

4.3.3.2 Statistical Analysis of Water Quality Improvements

To assess potential water quality improvements that could be associated with Phase I construction controls, EPA sought to identify jurisdictions that (1) experience a high rate of construction activity and (2) are located within a watershed that has been monitored for changes in water quality indicators. The water quality data used for this analysis came from the U.S. Geological Survey's National Stream Water Quality Monitoring Network (WQN). The construction data were U.S. Census Bureau building permit data.

Most of the currently available WQN data covers only the period from 1993 through 1995. On the other hand, Phase I construction controls were not put in-place until October 1992. Consequently, there were insufficient pre- and post-implementation WQN data to produce trend analysis with meaningful results.

Therefore, EPA conducted a surrogate analysis. This surrogate analysis is summarized here; a more detailed explanation is provided in Appendix F. The analysis required a high-growth area that had put erosion and sediment control provisions into place before the Phase I program and had requirements that were at least as rigorous as those required under the Phase I program. As a result of the screening analysis, the State of Florida was chosen to be profiled. In 1994 Florida had 24 high-growth counties, as defined in this analysis. Numerous U.S. Geological Survey (USGS) monitoring stations are located within the State, and the State had implemented the Coastal Zone Management Act (CZMA) in September 1981. The State of Florida, as a result of the unique biogeographic conditions found in Florida, included the entire State in the coastal zone. Furthermore, in 1986 Florida adopted a comprehensive beach management program under which all coastal counties were required to implement erosion and sediment control provisions for construction activities. The period from 1980 to 1986 represents the pre-erosion and sediment control conditions and the period from 1987 to 1994 represents the post-erosion and sediment control conditions.

To find evidence of reduction in sediment loads that can potentially be attributed to the implementation of erosion and sediment control provisions, annual sediment loads from each watershed had to be derived using WQN data and then compared to annual construction levels for the counties in the watershed.

Implementation of erosion and sediment controls at construction sites should reduce the total sediment load leaving the site and ultimately reaching nearby waterways. Consequently, the analysis is complicated by the fact that the average annual level of construction is not "fixed" between the before and after periods. Because construction levels are not constant, evaluation of whether erosion and sediment controls are reducing sediment loads cannot be based on total load reductions but instead must be based on the rate of change in sediment loadings (in relation to rate of change in construction). For example, if the construction rate decreased, the loading rate would be expected to have a greater rate of decrease, and if the construction rate increased, the loading rate should have a lesser rate of increase. For this analysis, this is referred to as "changing in tandem."

Table 4-2 shows the percentage increase or decrease between the first and second period for both sediment loadings and construction. When each watershed is analyzed separately, the results show a "change in tandem" for 5 of the 11 watersheds. In the final row of Table 4-2, the sediment loads and then the construction permits are summed over all watersheds. The result demonstrates that, in aggregate, both total sediment loadings and construction decreased. Although average annual construction decreased by only 5 percent, however, the average annual sediment load decreased by 31 percent. The rate of decrease for aggregate sediment loads is six times greater than the rate of decrease for aggregate construction. This is supporting evidence for the hypothesis that erosion and sediment controls are reducing construction site sediment loads in Florida watersheds.

Table 4-2. Comparison of Sediment Change and Construction Change for Each Watershed

Watershed	Average Annual Sediment (Tons/Inch of Rain)			Average Annual Number of Construction Permits From Corresponding Counties			Change in Tamden
	1980–1986	1987–1994	Change	1980–1986	1987–1994	Change	
Upper St. Johns	313	491	36%	67,063	65,384	-3%	-
Daytona	24	4	-483%	18,961	19,043	0%	+
Kissimmee	77	100	23%	43,495	45,577	5%	-
Western Okeechobee	14	20	27%	3,287	3,055	-8%	-
Caloosahatchee	254	113	-124%	19,270	18,317	-5%	+
Peace	1,871	187	-901%	32,004	27,465	-17%	+
Alafia	257	73	-253%	28,717	24,409	-18%	+
Santa Fe	52	83	37%	4,027	3,669	-10%	-
Yellow	534	519	-3%	2,671	3,163	16%	+
Perdido	210	243	13%	5,467	4,641	-18%	-
Escambia	4,609	4,449	-4%	5,467	4,641	-18%	-
Total	**8,215**	**6,282**	**-31%**	**230,429**	**219,364**	**-5%**	**+**

Note: From Table 4-2, the column heading "average number of construction permits" should not be confused with , or equated to the actual number of construction starts. Multiple permits may have been issued per construction start.

The aggregate results suggest that for each comparison it might be useful to look at the magnitude of the change in sediment loads and not just the direction of the change. For example, when sediment rates fell or rose in relation to the construction rates, was the magnitude greater than it was for those instances when they did not change in tandem? EPA used a Wilcoxon signed-rank test to compare the rates of sediment load increase or decrease and ranked the changes to determine if the magnitude was significant (‘Newmark, 1992). The results of the test were positive, providing additional evidence suggesting erosion and sediment controls have had a positive impact on water quality protection when the magnitude of the rainfall and corresponding sediment loads are considered. For a more detailed explanation of the Wicoxon signed-rank test and the results, refer to Appendix F.

4.4 FINDINGS OF THE REVIEW OF THE PHASE I PROGRAM FOR STORM WATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES

This section summarizes the analyses conducted for erosion and sediment controls for construction activities under the Phase I program. The successful elements of the Phase I program are identified. Additionally, Phase I program components that have been less successful and might need to be restructured are also discussed.

4.4.1 Successful Measures of the Phase I Program for Construction Activities

Successful elements of the Phase I storm water program for construction activities, and improvements in water quality associated with program implementation are discussed in this section. Although this analysis focused on controlling erosion and sediment at construction sites disturbing 5 or more acres, construction activities regulated under an MS4 permit, or similar state or local sediment and erosion control program may be subject to requirements specific to that jurisdiction. Many jurisdictions require erosion and sediment controls on construction sites smaller than 5 acres. Therefore, the actual water quality protection achieved from *all* required erosion and sediment controls is larger than the portion addressed in this analysis of the Phase I program.

<u>Phase I Program Flexibility</u>

EPA recognizes the Phase I program’s relationship to other federal, state, and local storm water control programs. Indeed, in designing the program EPA focused on integration of programmatic requirements so states and localities could leverage the Phase I program to support existing programs. The following case studies show that state and local programs have successfully integrated and leveraged the program to improve program administration and yield water quality benefits.

- The State of Delaware’s inspection certification program increased compliance at construction sites while reducing the costs of program administration. Studies have shown that erosion and sedimentation control practices implemented in New Castle County have reduced sediment in runoff an average of 84 percent (up to 600,000 tons of sediment retained from the 400 construction starts in the county).

- Within the North Carolina Department of Environment and Natural Resources, the Division of Land Resources (administering the Sedimentation Control Program) and the Division of Water Quality (administering the NPDES storm water program) have successfully integrated their functions to develop a comprehensive construction storm water program. Beaverdam Creek, a primary nursery area and high-quality water, had experienced turbidity exceedances due to poorly managed construction activities. Successful program integration enabled North Carolina to curb poor management practices at construction sites in Brunswick County, North Carolina.

Loads Averted

- A modeling analysis conducted for this report estimates that Phase I BMPs applicable to construction sites keep 73 percent of the sediments generated during construction from reaching surface water bodies. Using an average sediment load reduction per site (46.4 tons per site) and estimates of the number of permitted construction starts in 1999 (19,856 sites), the Phase I Program has prevented up to 882,000 tons of sediment from entering the Nation's waters.

Water Quality Protection

- EPA conducted an analysis to assess the correlation between the onset of similar statewide CZMA erosion and sediment control programs in Florida and water quality conditions. That analysis provided limited evidence of a positive relationship between the implementation of storm water controls on construction activities and the key water quality parameter of total suspended solids.

- A Phase I storm water construction permit in Grays Harbor County, Washington provided the mechanism to ensure that the development of a major Department of Corrections (DOC) facility would not threaten the nearby wetlands and salmon habitat of Stafford Creek and other surrounding water bodies. Before full implementation of the SWPPP, water quality exceedances were noted. After SWPPP implementation, there were no water quality exceedances.

4.4.2 Components of the Phase I Program That May Need to Be Addressed

The Phase I program has documented success stories. There are, however, limitations on EPA's ability to document program results on a national scale.

Few Mechanisms Exist to Identify Successful Program Elements

The Phase I Program is one of the many tools used to protect and improve the quality of the Nation's waters. It can therefore be very difficult to develop analyses that identify the specific contributions this program provides to water quality. There is insufficient post-implementation data collected for construction activities disturbing 5 or more acres. As a result, EPA is not able to conduct a pre/post analysis of national water quality improvements as a result of the implementation of BMPs at construction sites.